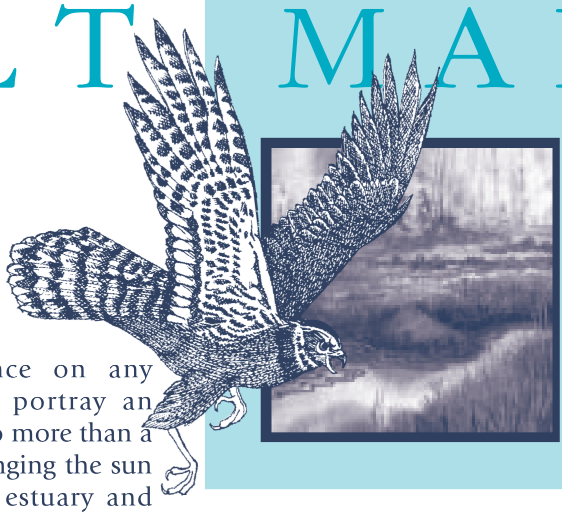
OREGON'S SALT MARSHES



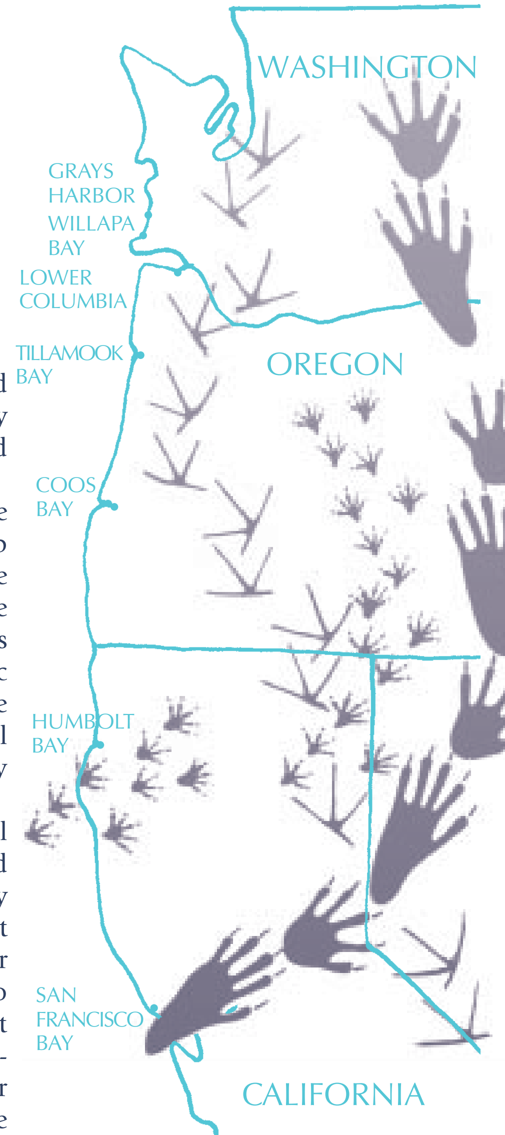
A distant glance on any summer's day might portray an Oregon salt marsh as no more than a docile field of grass, fringing the sun dappled waters of an estuary and swaying to the whims of the winds. Belying it's simple quiescence, however, are complex assemblages of plant and animal communities that rely upon this intricate wetland, many of which are uniquely adapted to the stresses of life in the salt marsh.

All coastal states contain salt marshes, which flourish near river mouths, in estuaries, and around lagoons in areas protected from battering ocean waves and storms. Along the Atlantic and Gulf coasts, salt marshes are widely dispersed and often sprawl over large areas. On the Pacific Coast however, they are relatively small and sparsely distributed, accounting for only three percent of the nation's total acreage, and making them all the more valuable for their scarcity. Oregon has only about 7,000 acres of salt marsh, amounting to approximately 17 percent of total estuarine acreage.

Salt marshes develop in coastal areas sheltered from the ocean's surf. In Oregon, they occur in the lower intertidal fringes of coastal rivers. Seaward portions of salt marshes emerge from sandflats, mudflats, or a combination of sandy mud. They rise shoreward and landward, forming a transition zone between estuarine and upland ecosystems, where they support an abundance of aquatic and terrestrial organisms.

Tides are the life blood of these unique habitats. Flood tides sweep sediments and nutrients into the marsh, which drop out and settle during slack-water periods. Ebb tides flush dead plants and other organic material out of the marsh and into the estuary, where they enter the detrital food chain and contribute significantly to estuarine food webs.

These natural processes, essential to the survival of many plant and animal species, are also immeasurably valuable to people. For example, as salt marshes maintain or improve water quality and furnish abundant food to countless organisms, they also support coastwide commercial and recreational fisheries and a thriving oyster industry. Moreover, marshes provide opportunities for both passive and active recreation—such as observing and photographing wildlife, hiking, canoeing, fishing, and hunting—as well as education and scientific study.



"Americans concerned about saving tropical forests' vast biological wealth must not lose sight of losses much closer to home, including the degradation of U.S. seashores, coral reefs, barrier islands, estuaries and coastal wetlands."

—James Gustave Speth, President
World Resources Institute

SALT MARSH BENEFITS AT A GLANCE

Salt marshes perform a variety of natural functions and provide values that are important to the overall health and welfare of estuaries and the well-being of estuarine plant and animal communities, as well as to the people who live and work near estuaries. Salt marshes provide:

- Shoreline erosion control and resistance.
- Floodwater retention and control.
- Water-quality improvement.
- Retention of nutrients.
- Food-chain and food-web support.
- Fish and shellfish habitat.
- Wildlife habitat.
- Fish and wildlife refuge.
- Recreational activities.
- Opportunities for education and research.

SALT MARSHES IMPROVE WATER QUALITY AND PREVENT EROSION

By trapping sediments, marsh plants reduce turbidity and filter excess nutrients, chemicals, heavy metals, and other pollutants from the water. Emergent marsh plants are also able to absorb raw or treated sewage, seepage from septic systems, animal wastes, and fertilizers. When bacteria decompose these organic materials, marsh plants take up the nutrients into their roots, stems, and leaves. In this way, salt marshes function as pollution buffers between the estuary and areas of urban and agricultural development.

Salt marshes also protect estuary shorelines in two important ways. Roots and rhizomes of marsh plants help bind soils, while emergent vegetation absorbs and dissipates wave energy and retards the forces of tidal flows and upland runoff, thus anchoring the shoreline and reducing erosion.

These functions combine to extend further protection to other crucial estuarine habitats and their residents. Intertidal and subtidal eelgrass beds, for instance, require adequate sunlight penetration to survive, so are intolerant of excessive turbidity. What's more, eelgrass is susceptible to uprooting by strong currents and storm waves. As salt marshes reduce the turbidity of water that passes through them and buffer the effects of currents and waves, they protect neighboring eelgrass meadows.

SALT MARSHES ARE IMPORTANT FISH AND WILDLIFE HABITAT

In addition to making major contributions to the productivity of estuaries, salt marshes also provide essential habitat to many organisms throughout their life spans or during certain life-history phases.

The range of species that depend on or at least visit the salt marsh runs the gamut from insects, snails, slugs, worms, and clams to fish, birds, and mammals.

Like eelgrass beds, salt marshes offer abundant food and refuge to animals of the estuary. Low tides, however, leave marshes high and dry twice a day, so terrestrial creatures are more prevalent than the aquatic species that must move in and out with the tides. Other marsh inhabitants, such as various worms and clams, deal with the waxing and waning of tides by residing and making a living in the marshes' bottom sediments.

Countless spiders and insects populate salt marshes during all but the winter months. Aphids, leafhoppers, leaf bugs, grasshoppers, and crickets consume plant juices and tissues and attract spiders and other carnivores. During the summer, marshes are abuzz and aflutter with flying insects, including flies, wasps, butterflies, and nature's version of the helicopter: the dragonfly, each capable of consuming 300 mosquitoes a day. Naturally, this tempting buffet of invertebrates invites many insect-eating fish, birds, and mammals.

By moderating water temperatures, salt marshes provide ideal spawning and rearing habitat for many marine and anadromous fishes. Salt marshes and adjacent intertidal and shallow subtidal flats absorb tremendous amounts of energy, which is not only essential for photosynthesis and plant growth, but also helps warm the chilly wash of incoming tides. Warmer water temperatures in late winter and spring are attractive to species that spawn in the lower marshes and eelgrass beds, as well as to the juveniles of many species, which seem to prefer warmer waters for finding food and shelter.

Estuaries are particularly valuable nursery areas for larval and juvenile fishes and shellfishes. During summer peaks, as many as 70 species of juvenile fishes forage in Oregon's estuaries. Some move into the salt marshes on high tide to find food and refuge from predators. Even fish that prefer the subtidal flats and deeper channels benefit indirectly from the salt marshes by consuming the organisms that feed on marsh detritus.

Salt marshes provide feeding, breeding, and nesting areas for several species of resident birds and waterfowl, as well as resting and overwintering areas for abundant migrating waterfowl and shorebirds. Although shorebirds outnumber all others in the salt marshes, ducks, geese, coots, herons, gulls, and crows are also common.

When high tide forces the short-billed dowitchers, semipalmated plovers, western sandpipers, and willets off the mudflats, where they feed on various invertebrates, they head for the higher ground of the marshes. Some are satisfied to snooze and preen themselves, awaiting the next low tide, while others head for the health-food section to devour the seeds of seaside arrowgrass, tufted hairgrass, sand spurry, and other marsh plants.

The Pacific flyway, a system of several north-south migration corridors, lies along the West Coast and extends some 700 miles inland. On its western edge, the largest estuaries are the main attractions to migrating flocks—namely, Grays Harbor, Willapa Bay, the lower Columbia River, Tillamook Bay, Coos Bay, Humbolt Bay, and San Francisco Bay. Most of the 3l species of waterfowl in the flyway use these estuaries and their bordering salt marshes.

Salt marshes also provide food and shelter for waterfowl and seabirds during weather extremes. When inland lakes and freshwater wetlands freeze, waterfowl flock by the thousands to Oregon's estuaries, particularly the larger ones. A big offshore storm can also send seabirds shoreward, providing coastal birdwatchers with rare glimpses of such species as red and northern phalaropes, which flee to the estuaries, seeking the calm waters of marshes to ride out the storm.

Ospreys nest and hunt for food along the edges of Oregon's estuaries; so do bald eagles, as far south as Coos Bay. The most common raptor of the estuary fringes, however, is the marsh hawk. This slim-bodied, broad-winged harrier glides and hovers over the high salt marshes, searching for and diving on mice and voles, as well as birds and occasionally small waterfowl, such as teal.

The most plentiful mammals of the upper marsh are mice, voles, and shrews, which feed mainly on insects and other invertebrates. Other mammals that may forage in the marshes include beaver, muskrat, mink, river otter, skunk, raccoon, and deer.

Oregon's salt marshes are among the richest sources of nutrition for the widest variety of animals. Where else might one find such disparate creatures as staghorn sculpins, cutthroat trout, snails, dragonflies, herons, mallards, Canada geese, deer mice, marsh hawks, skunks, raccoons, and black-tailed deer, all shopping for groceries in the same supermarket?

SALT MARSHES GROW FROM THE BOTTOM UP

The process that creates salt marshes is sedimentation, which occurs most rapidly and extensively in low-gradient estuaries, including most along the Oregon coast from the Coquille River north. South of the Coquille estuary, steep-gradient rivers, such as the Rogue and Chetco, experience minimal sedimentation and marsh building.

Sedimentation is a natural watershed process resulting, in large part, from runoff and erosion. The sediment load in Oregon's coastal rivers and creeks varies seasonally, being highest in winter and spring and lowest during the drier months. In most basins, erosion has been accelerated by road building, logging, agriculture, and forest fires, resulting in excessive sedimentation in some estuaries. In Coos Bay, for instance, sediments wash into the estuary at a rate of 72,000 tons a year.

Coastal streams carry fine particles of silts and clays to the estuaries, where they combine with sediments of marine origin to settle out of the water and form tidal flats. As subtidal sandflats and mudflats develop, they grow and eventually emerge as intertidal flats at low tide. When the flats reach sufficient elevation for inundation to decline and a few pioneer plants to take root, a new marsh begins.

Most marsh vegetation consists of perennial species with underground stems or rhizomes, which spread rapidly in all directions from the parent plants. As tidal and riverine waters flow over the area and drop out more sediments, the marsh continues to build itself. The more plants that become established, the more sediments the marsh is able to trap.

Typically, the first plants to emerge on sandflats are pickleweed, then sand spurry and three-square rush. On mudflats, composed of finer sediments, the first pioneers are usually seaside arrowgrass, spike rush, and sand spurry. As continuing sedimentation gradually increases marsh elevation, tidal inundation becomes less frequent and of shorter duration in the higher portions of the marsh. Eventually, different plant species begin replacing the colonizers, and at an elevation where tidal flooding is brief and infrequent and exposure to the air is nearly continuous, the high marsh becomes established.

Tidal cycles regulate the frequency and duration of inundation in the marsh. Consequently, the tides not only affect the salinity levels within the marsh, but are also responsible for how various species of plants sort themselves out. On the Oregon coast, high tides inundate low marshes twice a day. Flood tides might cover the surface of high marshes only a few times each year, during the largest spring tides. In between, the middle marsh areas might be submerged once a day or less frequently.

Although some plants can thrive in a fairly broad range of marsh elevations, most respond differently to such environmental conditions as salinity and submergence. So vegitation forms distinct zones in the salt marsh, each with its characteristic indicator species. Typical low-marsh indicators include seaside arrowgrass, pickleweed, and Lyngby's sedge. The hairgrass and common spike rush are high-marsh indicators. In the transition zone between the high marsh and upland, so-called nonindicator species include Pacific silverweed, redtop, and Baltic rush.

Much of the above-ground vegetation dies back in winter and decomposes over time, becoming part of the detritus on the marsh bottom. So salt marshes grow from a mixture of sediments derived from riverine and marine origins, as well as from organic materials produced by the marshes themselves.

SALT MARSHES ARE THE BREADBASKETS OF THE ESTUARY

Salt marshes are among the most biologically productive natural ecosystems on earth—outstripping even intensely used agricultural lands—mainly because of the way marsh plants live, die, and decompose. Long growing seasons, efficient plants, and an abundant supply of rich nutrients allow salt marshes to generate and store tremendous amounts of food that ride the tides into the estuary.

The longer growing season of marshes is attributed to the temperature-moderating effects of their aquatic environment. Unlike terrestrial plants, which are subjected to the seasonal extremes of the atmosphere, many marsh plants enjoy the semidiurnal bathing of brackish tidewaters, the temperature of which remains relatively constant through much of the year. Consequently, marsh plants are able to grow and produce earlier in the spring and later into the summer than most terrestrial plants.

Salt marshes absorb solar energy to produce phytoplankton, algal mats, and green plants essential to estuarine food webs. The vertical orientation of leaves on most salt-marsh plants exposes maximum surface area to sunlight throughout the day, reduces shading of adjacent plants, and decreases the likelihood of the leaves' overheating. Because of their shape and spatial attitude, marsh grasses, sedges, and rushes are capable of capturing up to three times as much solar energy as agricultural crop plants.

In early fall, colder water and decreasing sunlight bring the growth of most marsh plants to a halt. By mid-autumn, much of the above-ground marsh vegetation has died and begun to decompose. Although the quantity of dead marsh plants is greatest in winter, decomposition is most rapid in summer, but occurs all year.

Timing of vegetation decomposition is important for furnishing a fairly steady supply of nutrients to the estuary. Some plants, such as salt rush and saltgrass decompose slowly. Others, including pickleweed, decompose rapidly.

Tissues of the rooted marsh plants contain carbohydrates, such as cellulose and lignin, that few higher animals can digest. Consequently, direct consumption of marshes' flowering plants is relatively low, about l0 percent, and mainly confined to insects. The remaining 90 percent includes the emergent vegetation that dies back in the fall. Decomposers, beginning with fungi and bacteria, descend on this rich food supply and start breaking down and assimilating its nourishing tissues. Larger consumers, which are unable to directly digest the plant material, have no trouble dining on the fungi and bacteria. In this way, the decaying salt-marsh vegetation enters the detrital food chain. Most of the estuary's invertebrates consume the fine detritus and associated bacteria and are, in turn, consumed by higher animals.

Contributions of the marsh's aerial production to the estuary's detrital food chain ranges from as little as five percent in the high marsh to 100 percent in the low marsh, or an average of perhaps 75 percent of the marsh's annual production. The remaining 25 percent is left to enrich marsh soils.

WETLAND LOSSES IN PACIFIC STATES

Compared to other regions in the United States, the Pacific Coast didn't have an abundance of wetlands to begin with, so all historic losses must be viewed as excessive and future losses as unacceptable. Following are the wetland losses documented in the Pacific states:

STATE	LOSSES
California	91%
Oregon	38%
Washington	31%
Hawaii	12%
Alaska	<1%

NOT ALL HISTORIC MARSH LOSSES ARE PERMANENT

Diking, channeling, and filling of salt marshes have damaged and displaced many thousands of acres throughout coastal America. Wetlands were once extensive throughout much of the nation and were viewed as impediments to settlement, development, and progress. Even federal lawmakers saw them as wastelands of no apparent value. The Swamplands Acts of 1849, 1859, and 1860 promoted the diking and draining of wetlands by offering free land to those willing to transform them into valuable dry land for agriculture and other purposes.

All salt marshes in the Pacific Northwest have been altered to some extent, and most have been degraded or eliminated altogether. As much as 90 percent of these losses have been for agricultural development and consist of diking and draining of salt marshes to convert them to pastures and crop-growing fields.

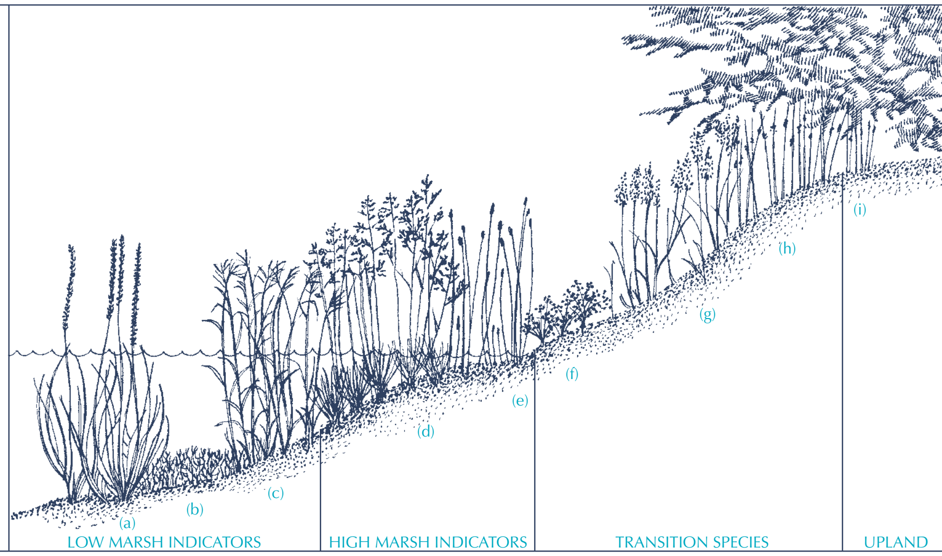
Since the l9th century, the natural functions of Oregon's salt marshes have been overshadowed by their obvious value as dry land. Compared to other coastal states, Oregon had relatively small salt marshes to begin with, but even those have been drastically reduced or obliterated, not only for agricultural purposes, but also for urban, industrial, and port development. In Coos Bay and Tillamook Bay, for example, only about 15 percent of the original marshlands remain.

Early logging and lumber operations also directly and indirectly took their toll on Oregon's coastal wetlands. With marshes fringing the shallow estuary shoreline areas,

INTERTIDAL SALT MARSHES OF OREGON

Generalized profile of an Oregon intertidal marsh. Although the plant species shown are prominent throughout their respective zones, they may also be found to some extent in the other marsh zones. Plants shown are: (a) arrow-grass, (b) pickleweed, (c) Lyngby's sedge, (d) tufted hairgrass, (e) common spike rush, (f) silverweed, (g) redtop, (h) Baltic rush, and (i) Sitka spruce.

Adapted from an illustration by Donna Klentz from a Sea Grant publication entitled "Intertidal Salt Marshes of Oregon."



earliest port and industrial facilities included long piers extending over the marshes, well into the estuaries where water was deep enough to moor ships. Eventually, those marshes were filled with dry ballast from the ships, sawdust from the mills, and spoils from the dredges used to keep navigation channels open. Coastal wetlands were also turned into fields for raising hay and oats to feed the livestock used in nearby logging camps.

Other industrial and recreational development beginning in the late 19th century and continuing through the 20th century led to the destruction of many more acres of Oregon's salt marshes and eelgrass beds, particularly on the larger estuaries. Accompanying the growth of commercial and sport fishing was the construction of docks, piers, canneries, processing plants, and marina complexes. Pulp and paper mills, marine fuel facilities, boat building and repair, and maritime commerce all led to waterfront development and urban expansion, often in filled marshes. The salt marsh that once spread into the upper end of Coos Bay's Kentuck Inlet is now an 18-hole golf course.

Federal and state laws now protect Oregon's remaining salt marshes and encourage marsh enhancement and restoration wherever possible. Large, permanent structures and certain other modifications prevent the restoration of many marshes. Most of those that were diked and drained for agriculture, however, may be reclaimed and restored to some, if not all, of their original natural functions.

After more than 150 years of salt-marsh and other wetland degradation and destruction on the West Coast, the potential of wetland enhancement, restoration, and even creation is promising. The prospects of restoring these natural treasures and their many valuable ecosystem functions are exciting, and new opportunities exist to regain lost coastal-wetland habitats.

So far, however, most wetland restoration projects have been mitigation trade-offs, required by federal and state regulations when permitted development projects lead to wetland modification or destruction. Although the state of Oregon has adopted a "no-net-loss" policy for wetlands, mitigation, at best, results in no gain. Moreover, many if not most, mitigation efforts have failed to live up to expectations.

Although federal and state regulations have been formulated to preserve the size and integrity of existing wetlands, they may not sufficiently account for the current inadequacies of a relatively new science or the sometimes disappointing results of its applications. Scientists and resource managers cannot always accurately predict which enhancement and restoration methods will work. Another uncertainty they face is whether mitigation trade-offs will prove to be fully compensatory—that is, whether a wetland restored under mitigation regulations will provide all the natural functions lost in the permitted development area. As Steve Eggers of the U.S. Army Corps of Engineers put it, "Wetland regulations are perhaps 20 years ahead of the science."

Perhaps science and technology will catch up in the new millennium. Regulations might be refined to accommodate the lag time, provide better protection for existing wetlands, and promote more widespread restoration and enhancement programs. At any rate, a growing number of people realize that salt marshes and other coastal wetlands are natural treasures that must be preserved, and that's a good start.

Once viewed as wastelands to be filled and developed, salt marshes are now recognized as unique ecosystems that perform crucial natural functions that benefit fish, wildlife, and people. The precious marshes are essential to the welfare of Oregon's estuaries and their inhabitants. They are of immense and immeasurable economic and aesthetic value, not just to the people who live and work along the shores of the estuaries and throughout the coastal river basins, but to all Oregonians and others who enjoy visiting the Oregon coast and experiencing the wonders of the estuaries.

ARCATA MARSH AND WILDLIFE SANCTUARY

Only a couple of decades ago, scientists began theorizing that the ability of wetlands to remove pathogens and other contaminants from water might be used to improve the quality of wastewater discharged by sewage-treatment plants. Since then, integrated wastewater-treatment projects developed in several parts of the nation have not only been successful, but have also proved to be cost-effective ways to handle municipal wastes while providing wildlife habitat and aesthetically pleasing natural areas suitable for aquaculture, recreation, education, and scientific research.

One such innovative treatment facility lies at the north end of Humbolt Bay, in northern California, on the outskirts of the city of Arcata. Known as the Arcata Marsh and Wildlife Sanctuary, this 154-acre complex includes both restored and created wetlands, consisting of three freshwater marshes, two salt marshes, a creek-fed slough, and a brackish-water lake, which function in concert with Arcata's sewage-treatment plant.

AQUACULTURE

Another component of the Arcata Marsh and Wildlife Sanctuary is an aquaculture project operated by the fisheries department of nearby Humbolt State University. The facility includes a hatchery where the eggs of several species of fish—including chinook and coho salmon, as well as steelhead, cutthroat, and rainbow trout—are collected, fertilized, incubated, and hatched. The juvenile salmonids are then reared to the smolt stage in ponds containing equal parts of seawater and nutrient-rich treated wastewater. The fish are then used to augment local salmonid runs and for stocking Franklin Klopp Lake, which is part of the marsh and sanctuary complex.

WILDLIFE HABITAT

The lush greenery of more than 100 species of wetland and upland plants provides food and cover for some 300 species of birds, mammals, and fish, which are either permanent residents of or seasonal visitors to the sanctuary. Of all the many animals using the area, birds and waterfowl are the most visible. About 200 species of birds and waterfowl use the marshes, uplands, and adjacent bay, with greatest numbers occurring during spring and fall migrations.

RECREATION AND TOURISM

Once a leachate basin for a sanitary landfill that operated in the l960s and '70s, Klopp Lake is a brackish-water recreational lake that's popular with anglers and birdwatchers. Hiking trails extend along the lakeshore, and several blinds provide cover and shelter for anyone interested in observing the abundant birds and waterfowl the lake attracts.

In addition to sport fishing and birdwatching, recreational opportunities at the sanctuary include biking, hiking, jogging, and wildlife photography. What's more, the area not only draws local residents, but also attracts more than 100,000 visitors each year.

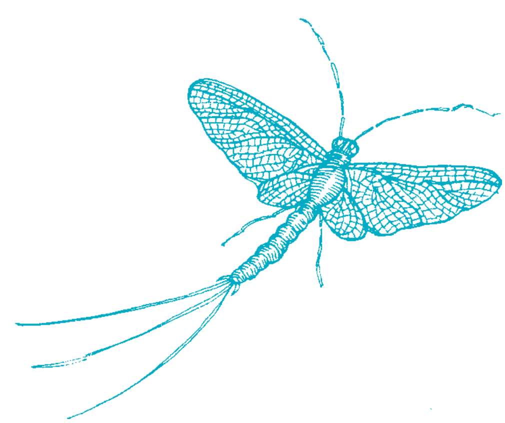
EDUCATION AND RESEARCH

The Arcata Marsh and Wildlife Sanctuary is a great spot for field trips by students of all ages. Here, teachers can offer firsthand demonstrations and observations of the importance of marshes as habitat, and can point out how science and technology are working with nature to provide benefits to both wildlife and human populations.

The complex offers opportunities for field research in a number of disciplines, including the biological sciences, wildlife management, and environmental resources engineering. It's also a good place for wildlife artists, outdoor photographers, and nature writers to find subjects and hone skills.

AFFLUENT EFFLUENT

Arcata residents have not only taken care of their sewage problems, but in so doing have created, for themselves and others, abundant natural wealth and beauty. On any sunny day at the Arcata Marsh and Wildlife Sanctuary, locals and tourists turn out to hike and bike, watch and photograph wildlife, enjoy picnics or sack lunches, hold outdoor classes and business meetings, or just kick back and soak in the great outdoors—all at the local sewage-treatment plant!



ARCATA MARSH AND WILDLIFE SANCTUARY—continued

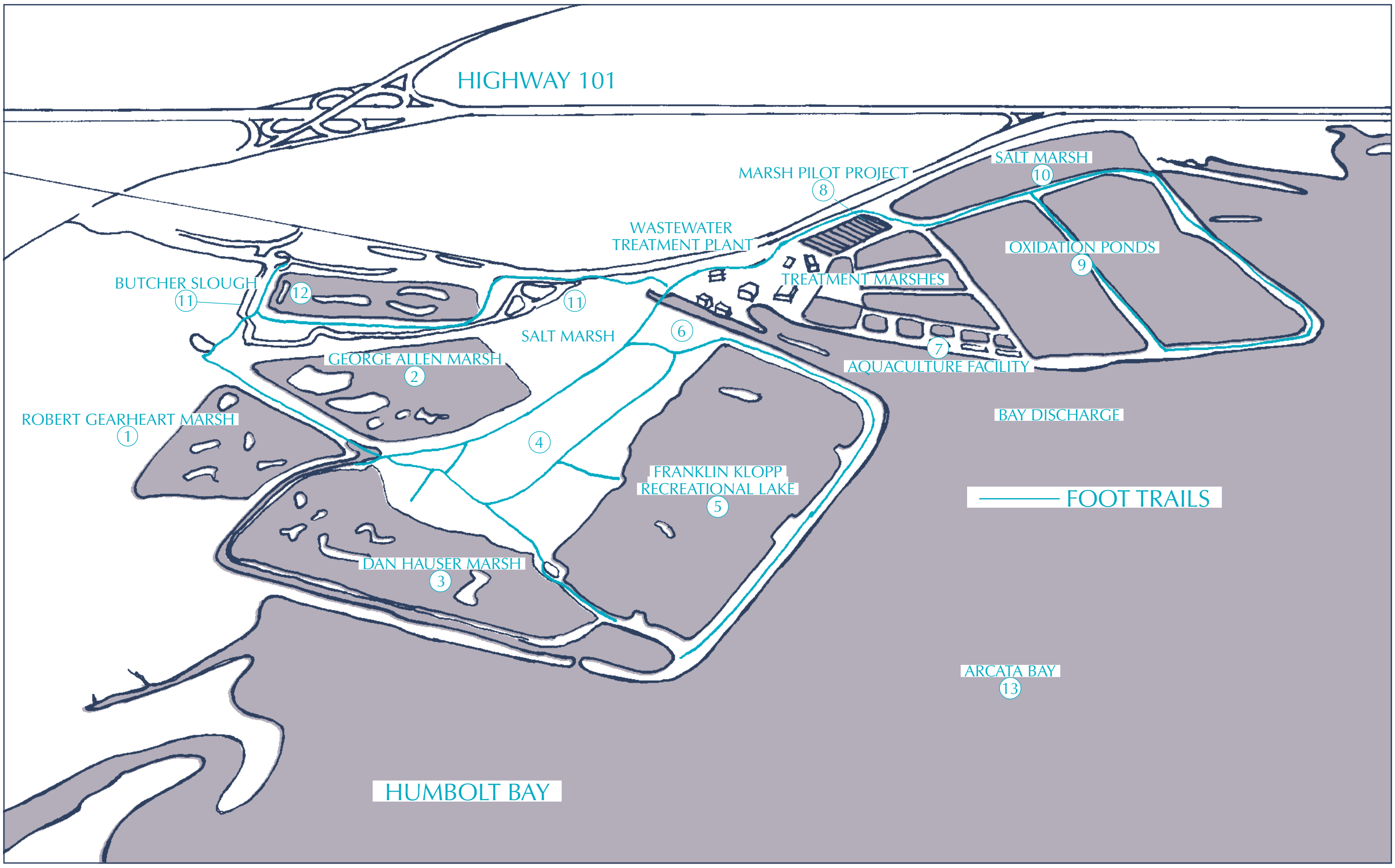


Illustration courtesy of City of Arcata.

1. Robert Gearheart Marsh: Completed in 1981, this marsh was built from pastureland and now uses treated wastewater as the sole water source.

2. George Allen Marsh: Also completed in 1981, this marsh was built on an abandoned log deck and is enhanced with wastewater.

3. Dan Hauser Marsh: The final marsh to be irrigated with treated wastewater before returning to the treatment plant and discharged to the bay. This marsh was once a leachate basin for the county landfill.

4. Mount Trashmore: This grassy hill has been reclaimed from a sealed sanitary landfill that operated during the 1960s and 70s.

5. Franklin Klopp Lake: This brackish lake, originally a leachate basin for the landfill, is now most popular for shorebird observation and sports fishing.

6. Looking east from this point affords a great view of the headworks (green buildings) and the oxidation ponds of Arcata's Wastewater Treatment Plant.

7. Wastewater Aquaculture Project: Fish hatchery and ponds where salmon, trout and other fish are raised in a mixture of wastewater and seawater.

8. Marsh Pilot Project: These ten 20' x 200' marshes were used to demonstrate the effectiveness of wetlands for treating wastewater.

9. Oxidation Ponds: These 45 acres of ponds, built in the late 1950s, treat Arcata's Wastewater to secondary standards.

10. Arcata Salt Marsh: Opened up to tidal flushing in 1981, these marshes are characteristic of the habitat around Humboldt Bay.

11. Butcher's Slough (lower end of Jolly Giant Creek): The pilings once supported a plywood mill until the area was restored 1985–86.

12. This fish ladder was constructed to aid in the capture of Coastal Cutthroat Trout. The ladder will be kept in this pond as part of a Humboldt State University/City of Arcata enhancement program.

13. Arcata Bay: The Bay produces more than half of the oysters grown in California and is home to a variety of other aquatic animals.

GLOSSARY

anadromous *n.* (of fish) hatching in fresh water, migrating to salt water, and returning as adults to fresh water to spawn.

aquaculture *n.* the cultivation of aquatic plants or animals in controlled or natural freshwater, saltwater, or estuarine environments.

brackish *adj.* slightly salt, as some estuarine water, with salt content usually ranging from 0.5 to 1.7 percent.

carnivore *n.* an animal that consumes flesh or other animals.

community *n.* a group of species populations occurring in the same place at the same time.

creation *n.* establishment of wetland functions and communities where no wetland previously existed.

detritus *n.* loose, finely divided rock or remains of organic tissues.

enhancement *n.* use of management techniques to increase or improve one or more functions of a wetland without changing wetland type.

food chain *n.* the interdependent arrangement of organisms within an ecological community, in which those of the lowest order are fed upon by larger organisms and in turn become food for still larger animals.

food web *n.* the entirety of interrelated food chains within an ecological community.

halophyte *n.* a plant that thrives in salty soil.

intertidal *adj.* above the low-water mark and below the high-water mark.

pathogen *n.* any bacterium, virus, or other microorganism that produces disease.

preservation *n.* the setting aside of wetlands in their existing condition.

restoration *n.* full or partial re-establishment of historic wetland conditions that previously existed but where wetland functions and communities have been reduced or no longer exist.

rhizome *n.* a rootlike, usually horizontal, underground stem that produces roots and sends up shoots that emerge aboveground.

salmonid *n.* any fish belonging to the family *Salmonidae*, including chars, salmons, trouts, and whitefishes.

salt marsh *n.* a brackish wetland created by sediments of riverine and marine sources, which is periodically inundated by high tides, and where specially adapted plant and animal communities thrive.

semidiurnal *adj.* occurring twice daily.

smolt *n.* a young anadromous salmonid in the seaward-migration stage of its life.

spring tide *n.* the large rise and fall of the tide coinciding with the new or full moon.

subtidal *adj.* below the low-water mark.

succulent *n.* a plant having fleshy, liquid-filled tissues. —*adj.* having fleshy leaves and stems.

turbidity *n.* the state of being unclear or cloudy because of stirred-up sediments, algal blooms, and the like.

watershed *n.* the drainage area of a river or other stream.

wetland *n.* land that has wet, spongy soil, as a bog, marsh, swamp, or wet meadow.

RECOMMENDED READING

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WEB SITES

National Estuarine Research Reserves:
http://wave.nos.noaa.gov/ocrm/nerr/welcome.html

South Slough National Estuarine Research Reserve:
http://www.southsloughestuary.com

Tillamook Bay National Estuary Project:
http://osu.orst.edu/dept/tbaynep/nephome.html

The Oregon Estuary Plan Book:
http://www.inforain.org/epb/intro.htm

Arcata Marsh and Wildlife Sanctuary:
http://www.humboldt.edu/~ere_dept/marsh

NOAA Web Sites: http://www.websites.noaa.gov

U.S. Environmental Protection Agency:
http://www.epa.gov

U.S. Army Corps of Engineers:
http://www.usace.army.mil

Office of Wetlands, Oceans, and Watersheds:
http://www.epa.gov/owow

Federal Web Locator:
http://www.law.vill.edu/fed-agency/febwebloc.html

Bioregional Information on North American Rainforest Coast: http://www.inforain.org

Coastnet Links to Other Sites:
http://secchi.hmsc.orst.edu/coastnet/links.html

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Tillamook Bay National Estuary Project

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